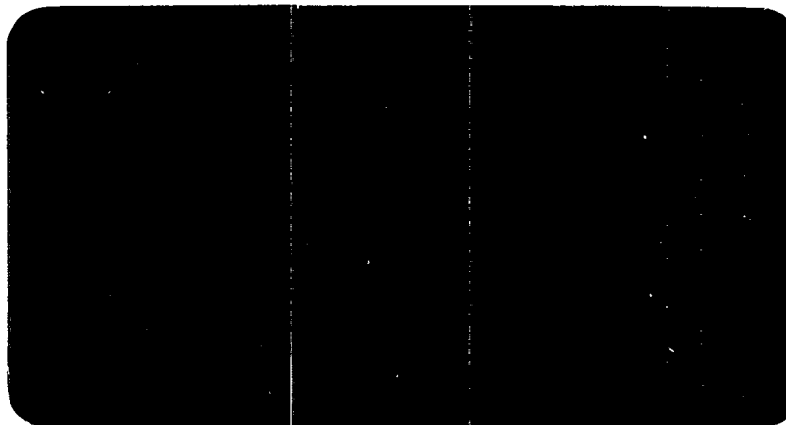# Image Cover Sheet

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TITLE

OBSERVATIONS ON THE APPLICATION OF HUMAN ENGINEERING IN THE ARDS/ADM PROJECT, PHASE 2

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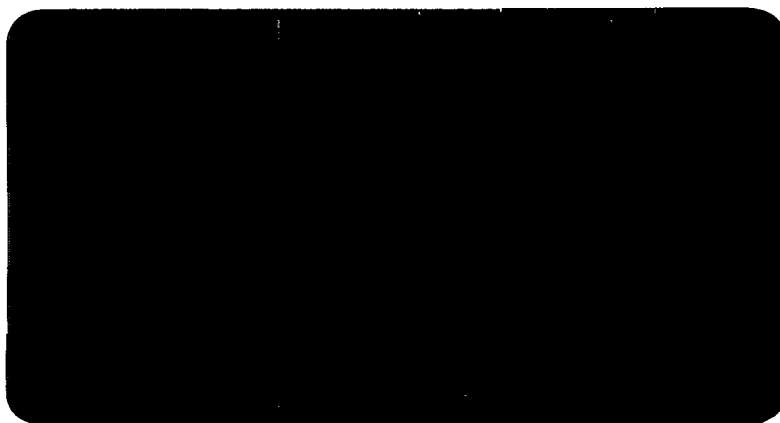**National   Défense**
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July 1994

DCIEM No. 94-32

OBSERVATIONS ON THE APPLICATION OF HUMAN ENGINEERING IN THE ARDS/ADM PROJECT, PHASE 2

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EXECUTIVE SUMMARY

This report documents observations on the application of Human Factors Engineering (HFE) in the System Requirements Phase of the Artillery Regimental Data System Advanced Development Model (ARDS/ADM). The observations have two purposes: to provide feedback to the Project Management Office (PMO) and the ARDS/ADM team on events and steps taken concerning HFE; and to serve as a source for a lessons learned analysis in order to improve the application of HFE in subsequent Command, Control Information System (CCIS) developments.

Three actions were undertaken by the PMO in order to augment the quality of HFE in the project: the organisation of an HFE Workshop, an HFE training course for the contractor, and the monitoring of the application of HFE in ARDS/ADM by a DCIEM scientist. The contractor responded by adding a human factors specialist to the ARDS/ADM team. The main conclusions of the monitoring effort are described below.

The workshop had a direct impact on the application of HFE in the project. The benefits of involving a human factors specialist were discussed and the contractor was introduced to the concepts of user-centred design. Several HFE activities were considered such as task analysis, cognitive modelling, and prototyping - resulting in the identification of the need for a training course in HFE.

The training course gave the team an understanding of what must be done to adopt a user-centred approach to system design and the resources required. The use of a worked exercise - including function allocation, task analysis, generation of an Operational Sequence Diagram, and creation of a prototype - was particularly valuable for assessing the benefits and costs of these techniques. Moreover, the course provided the opportunity for the team to focus on HFE issues and reach a common understanding of their application.

After the HFE course (September '93 - March '94), the main HFE effort of the team was devoted to the decomposition and allocation of functions. Twelve artillery mission descriptions were prepared by one subject matter expert (the Technical Resource Liaison Officer, or TRLO) and reviewed by the Deputy Project Manager (DPM) and a committee representing the stakeholders of ARDS (The Committee on ARDS, or CARDS). One mission, the Quick Fire Plan (QFP), was selected as the most representative of the activities of the artillery close support task. Some prototyping was done for this mission and presented to user representatives at the System Requirements Review meeting.

It is concluded that the mission descriptions and function decompositions will serve as the backbone for system functionality specifications from a user perspective and that this is a clear advance in the use of HFE by the project team. One risk with the process is the heavy involvement of a single subject matter expert in the mission description. The CARDS group is seen to play a crucial role in mitigating this risk.

Phase Two of the ARDS/ADM project ended with the System Requirement Review meeting. At the meeting a presentation of future functionality using a mission analysis provided the stakeholders with good insight into what to expect from the system. Narrative mission descriptions in conjunction with the List of operational Capability Deficiencies are a powerful means for discussing user requirements and engineering perspectives. Review of the more system-oriented System Software Specification document was less adequate for this purpose.

At the end of Phase Two of the project it is concluded that, in addition to the workshop and training course activities, the addition of a human factors specialist to the project team and the involvement of the user community has had a positive affect. While progress has been made, system

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engineering and human factors engineering activities were not completely integrated, possibly due to the incremental growth of the HFE focus. Observations on HFE activities in the ARDS/ADM project will continue throughout the life of the project using a human factors specialist under contract to DCIEM. Those observations will be used to develop a generic approach to the application of HFE in CCIS for CF projects.

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ABSTRACT

This report documents observations on the application of Human Factors Engineering in the System Requirements Phase of the Artillery Regimental Data System Advanced Development Model (ARDS/ADM). A Workshop and a course on Human Factors Engineering helped the ARDS/ADM team to focus on function and task analysis and function allocation. Mission descriptions of the future tasks of the artillery served an important role in discussions between engineers and users. The problem of feeding the system engineering activities with results of the human factors engineering activities was identified. Users were well represented, but user involvement should be broadened in following phases. Recommendations are given for future projects.

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1

INTRODUCTION

It was recognised that there was a need to capture the experience of the application of Human Factors Engineering (HFE) in the development of the Artillery Regimental Data System Advanced Development Model (ARDS/ADM). This report will give a record of the most relevant events and decisions that affected the application of HFE in the System Requirements Analysis phase of the project. The intention is that the report serve as a source for a lessons learned analysis in order to improve the application of HFE in subsequent Command, Control Information System (CCIS) developments.

The ARDS/ADM project will develop and test software that provides computer assistance for selected artillery procedures within the close support artillery regiments. The ADM will be tested in full field trials in order to get a proof of the system concept in terms of functionality and effectiveness. The project runs from 1992 to 1997 with the following phases: Operational Concept Definition (- Mar. '93), System Requirements Analysis (- Feb. '94), System Design (- Sept.. '94), Build, Integrate, and Test, and Field Trial (- '97).
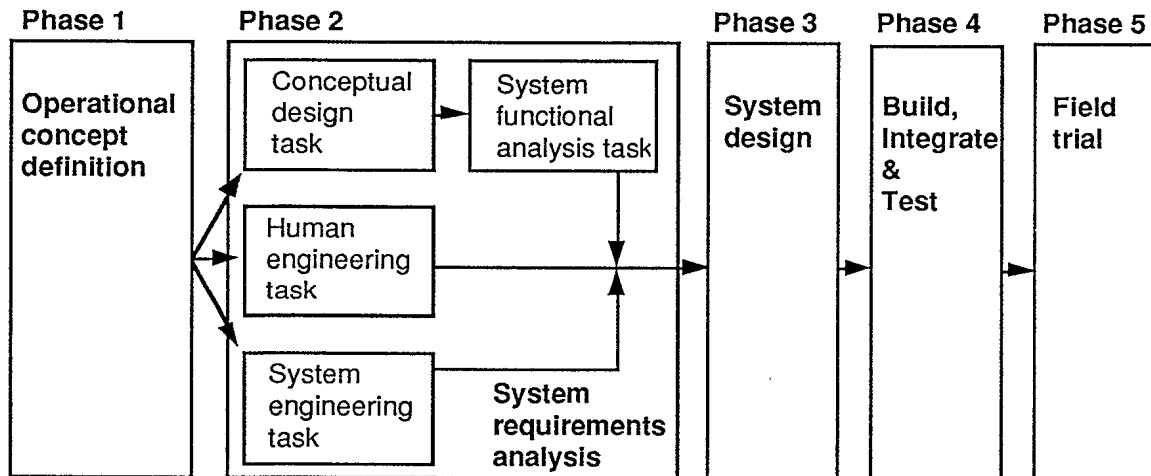

Figure 1: The five system development phases of ARDS/ADM with detailed tasks for Phase 2

In the initial phase of the project, HFE was given limited emphasisi. However, due to Project Management Office (PMO) interest and DCIEM involvement, there has been a considerable increase in attention to HFE in the project up to now (Feb. '94). In particular, attention is being given to analysis of the functions and tasks considering characteristics of the human operator. The increase in HFE effort was based on the recognition by the PMO and the user community that Human Factors is a risk factor in the development of information systems. Reducing the risk will increase the chance of success of the development.

The ARDS Project Manager (PM) asked that DCIEM provide HFE advice to the project. DCIEM personnel reviewed the project plan and their relevant expertise. Because of its focus on applied research rather than development, DCIEM does not have experience or a technology base in the application of such an approach. In discussions with the PMO and Directorate of Research and Development Land (DRDL), it was agreed that an evolutionary, user-centred approach was

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desirable for CCIS development. It was also agreed that the existing specification for the application of HFE in military system development (US MIL-H-46855B) was not ideal for such an approach, although it does not preclude iterative development.

Early in 1993 the idea developed that a workshop on HFE should be organised, using the ARDS/ADM project as a worked example. The intentions were to discuss HFE issues with specialists and the ARDS/ADM team and to develop an approach for the application of HFE in Command and Control Information Systems. Subsequently, the application of HFE was to be monitored over the duration of the project with the aim of identifying 'lessons learned' from the HFE perspective. Following the workshop, a scientist from DCIEM continued to meet with project management and contractor personnel, and to participate in discussion of issues related to the implementation of HFE. The scientist attended design/project review meetings and meetings of the Committee on ARDS (CARDS) which was formed to represent users' views on the development. DCIEM maintained a diary of observations which provided the material for this report - for the period July 1993 - March 1994. A contract was let to a human factors consultant to continue this work from March 1994 to the end of the project. The aims of this follow-up effort were:

- to make observations on the application of HFE through participation in project meetings and compare this to the Generic HFE Plan for CCIS developed at the workshop (Beevis, Essens, & Mack, 1993, DCIEM Report No. 93-42 pp. 141-146)
- to compare the normative goals of the HFE plans documented in US MIL-H-46855B (US DoD, 1979), DCIEM report no. 93-42, the ARDS/ADM contractor's HFE plan, and the generic HFE plan for CCIS being developed at DCIEM[1] with actual practice and identify reasons for any differences
- to gather information to clarify the major issues identified during the workshop (Beevis, Essens & Mack, 1993 pp. 122-137).

This report discusses how HFE was incorporated into the project and presents the observations of the process made during the System Requirements Analysis (SRA) Phase of ARDS/ADM. Each section is summarized with conclusions, some of which are generic, and some of which are specific to the ARDS/ADM project.

PLANNING FOR HFE IN ARDS/ADM

The ARDS/ADM Statement of Work (SOW, 4 June 1991) required the application of Human Engineering (synonymous with Human Factors Engineering, HFE) as part of the System Design. The Statement of Work (SOW) contained no particular instructions or Data Item Descriptions (DIDs) as to what HFE activities were required. Moreover, personnel qualifications in the area of HFE were not marked as essential. From the PMO plan for Evaluation of the Bidders' Proposals (Version 2), it is possible to derive how HFE was seen at the outset of the project. HFE qualities evaluation was referred to as follows:

"The Bidder should consider the following from ANSI/HFS 100-1988 in his outline plan:
- working environment: illuminance, glare, etc.
- visual display: resolution, contrast, colours, blinking, character height/format, etc.
- user-computer interface: keyboard, touch screens, mouse, ball, etc.
- furniture: ease of adjustment, work surface, etc.
- measurement techniques: tests for all conditions."

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[1] The generic HFE plan for CCIS development is the subject of a separate DCIEM report, in draft at the time of writing.

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Systems Engineering Activities/Products   **Human Engineering Activities/Products**
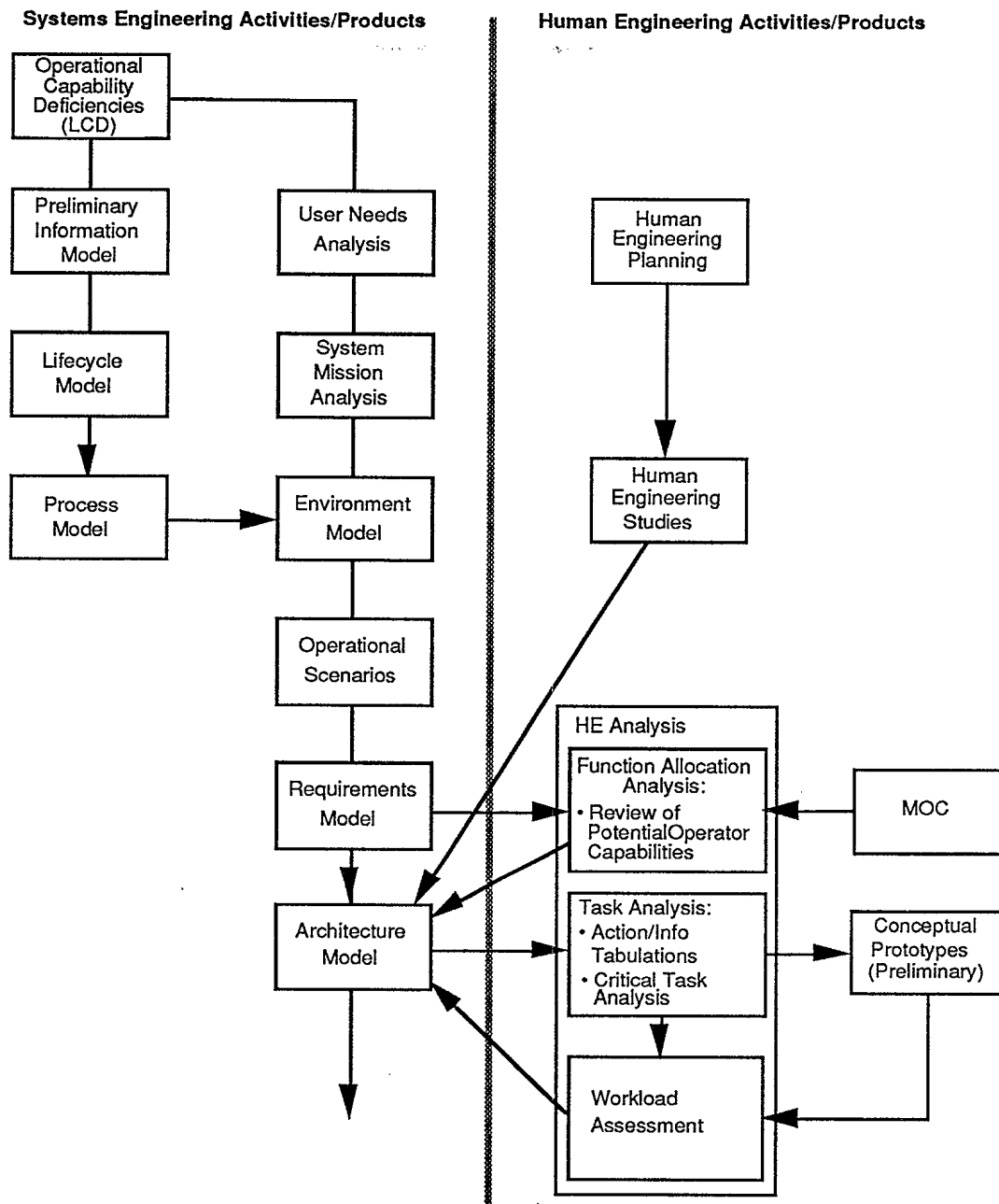
Figure 2: System Requirements Analysis (Phase 2) activities planned for ARDS/ADM
(after Clemens, 1993)

In 1991 DCIEM was invited to comment on the Human Engineering Project Plan (HEPP) submitted by MacDonald-Dettwiler and Associates (MDA) as prime contractor. The contractor proposed following a MANPRINT (Manpower and Personnel Integration) approach to HFE. The stated objectives of the HFE effort were "to simplify operator and maintainer tasks, and enhance operator performance through efficient display and control design." DCIEM noted that there are several advantages to adopting an approach based on MANPRINT. First, MANPRINT is aimed at minimising life-cycle costs by taking an integrated approach to the issues of manpower, personnel, training, human factors engineering, health hazards, and systems safety. Second, MANPRINT is

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user-centred. One of the tools of MANPRINT is the Early Comparability Analysis, which identifies critical operator and maintainer tasks based on comparison with similar tasks in existing systems; another MANPRINT tool is the Target Audience Description, which identifies the kinds of personnel for which the system should be designed. Thus a MANPRINT approach might be well suited to the ARDS/ADM project because of the emphasis it places on the system users. However, the contractor did not continue the proposed MANPRINT approach in subsequent versions of the HEPP.

DCIEM Human Factors Division assigned their army liaison officer (a Major responsible for liaison with army projects) to support the project. The officer was tasked with critiquing the proposed MANPRINT approach and exploring the Target Audience Description (TAD) for ARDS/ADM. The officer did not make any progress in defining the TAD prior to being posted from DCIEM. DCIEM also provided the contractor's team with a copy of a NATO report on HFE analysis techniques (NATO AC/243 (Panel-8)TR/7, Beevis et al., 1992) to assist them in defining the HFE approach.

An overview of the contractor's planned Phase 2 activities is given in Figure 2. The Requirements Model (system behaviour model) represents the functional requirements derived from systems engineering analyses. Those analyses were mainly the Preliminary Information Model, System Mission Analysis, and the list of Operational Capability Deficiencies (LCD) which was prepared in Phase 1. The Requirements Model was to include "those characteristics that are of concern to the users" (Clemens, 1993).

In a parallel HFE effort, the HE analysis was to cover function allocation and task analysis, as well as specific HE studies. Through Function Allocation Analysis, functions were to be allocated to computer software, hardware critical items or to personnel to be performed manually. The function allocation was to be driven by the development of the Requirements Model. The function allocation results were, in turn, to provide input to the development of the Architecture Model. In the formalism followed by the contractor, architecture modelling specifies the system architecture needed to support the requirements; it "converts physical user inputs (such as keyboard entries) into logical inputs .... and takes the system's logical outputs and converts them into physical form" (Clemens 1993). The model defines performance of the proposed system based on the allocated functions to determine system throughput and whether response times are acceptable. The Architecture model was to feed the operator task analyses and workload analyses.

MDA compared the project activities planned for phase two with the activities discussed in the NATO report on HFE analysis techniques (Figure 3). According to MDA (in a note to the PMO on 4 May '93) the major difference between the two approaches is in Function Allocation. In the ARDS/ADM approach, function allocation is performed in the Architecture model (see below). The architecture is analysed through task analysis and workload analysis. The note summarised the six HFE related tasks defined in the Project Management Plan:

- HE planning: Identify HE related activities, techniques, and tools; develop an approach that is consistent with the systems engineering approach
- HE studies: Define and evaluate HE prototyping environment and user interface hardware; develop interface style guide
- HE analysis: Driven by the results of the Behaviour model, determine type of data to be entered or displayed; analyse function allocation, including supervision, monitoring, consultation and training requirements
- Conceptual HE prototyping: Driven by the results of the HE studies and HE analysis, generate conceptual prototype of critical user interface elements
- Architecture model - User interface requirements: Driven by the results of the HE analysis and relevant design standards, define HE/Human performance requirements and allocate them to Critical Items of the system

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- System Model: Review the results of the Architecture model in order to update it before start of definition of software specification documents (System/Segment Design Dcouments - SSDDs) .

Two of these activities, HE planning and HE studies, are not addressed in the NATO report on human engineering analysis techniques (Beevis et al, 1992). Development of the Architecture model was not itself an HFE activity, but it was planned that the model be used as the main link between HE function and task analysis activities and other system engineering activities.

As shown in Figure 4, the task analyses were also planned to provide information for developing the operator training scheme. Although operator system performance and manning and training requirements were mentioned in the contractor's Human Engineering Management Plan (HEMP, equivalent to the HEPP), the work items did not detail how those issues would be approached.
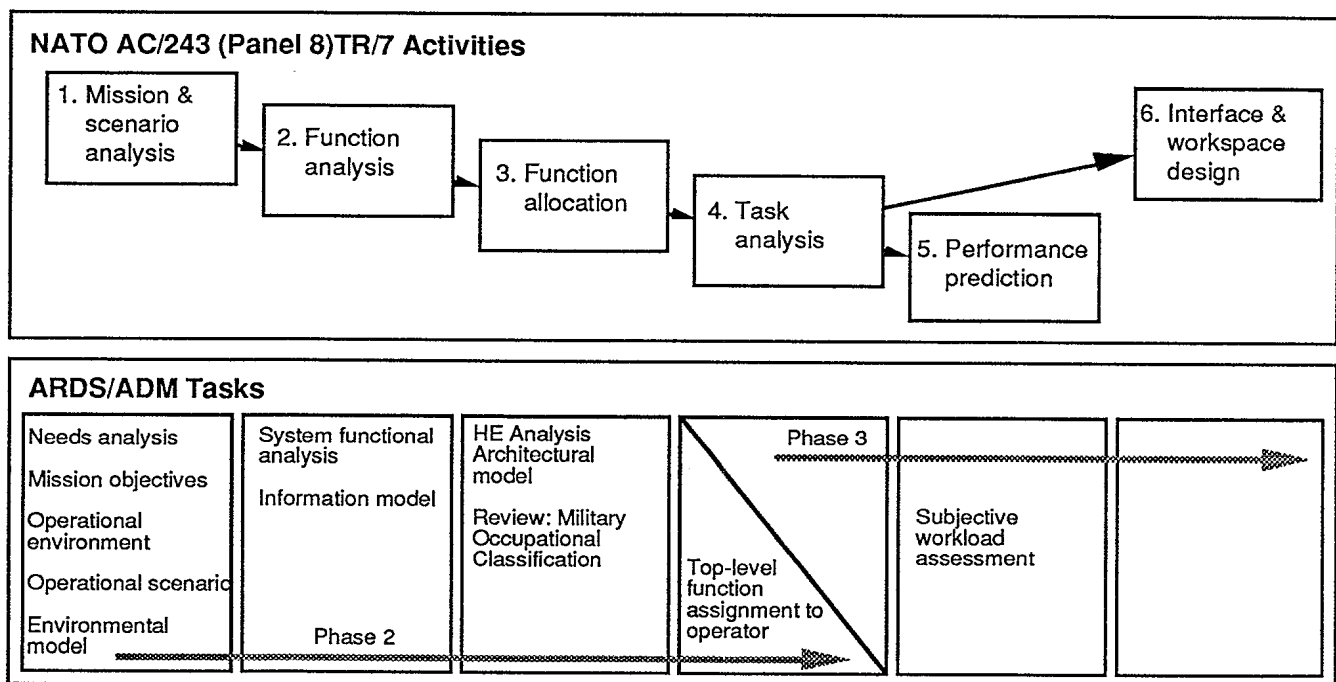

Figure 3: HFE activities anticipated for System Requirements Analysis (Phase 2) of ARDS/ADM

It was not clear to DCIEM how the specific nature of the HFE activities would be dealt with in the project. Initially, one member of the contractor's team was to be responsible for HFE on a part-time basis. Later approaches distributed HFE responsibilities across several members of the contractor's team, rather than making it the responsibility of one specialist. The PMO felt that more visible HFE tasks and the involvement of an HE specialist would reduce the risk associated with user acceptance.

Although the level of effort was increased, the HFE activities were not tightly coupled to other systems engineering activities. This may have been because the Architecture model was not developed in Phase 2. At the time of writing, it is not clear how the function allocation analyses and the task analyses will affect the Architecture model, when developed, and vice versa. Although many HFE activities parallel other systems engineering activities (Beevis et al., 1992), true

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integration of HFE and other systems engineering activities occurs when they use common information, models and tools. Applying this as a criterion, it is clear that there was little true integration of HFE and other systems engineering activities during Phase 2 of the ARDS/ADM project.
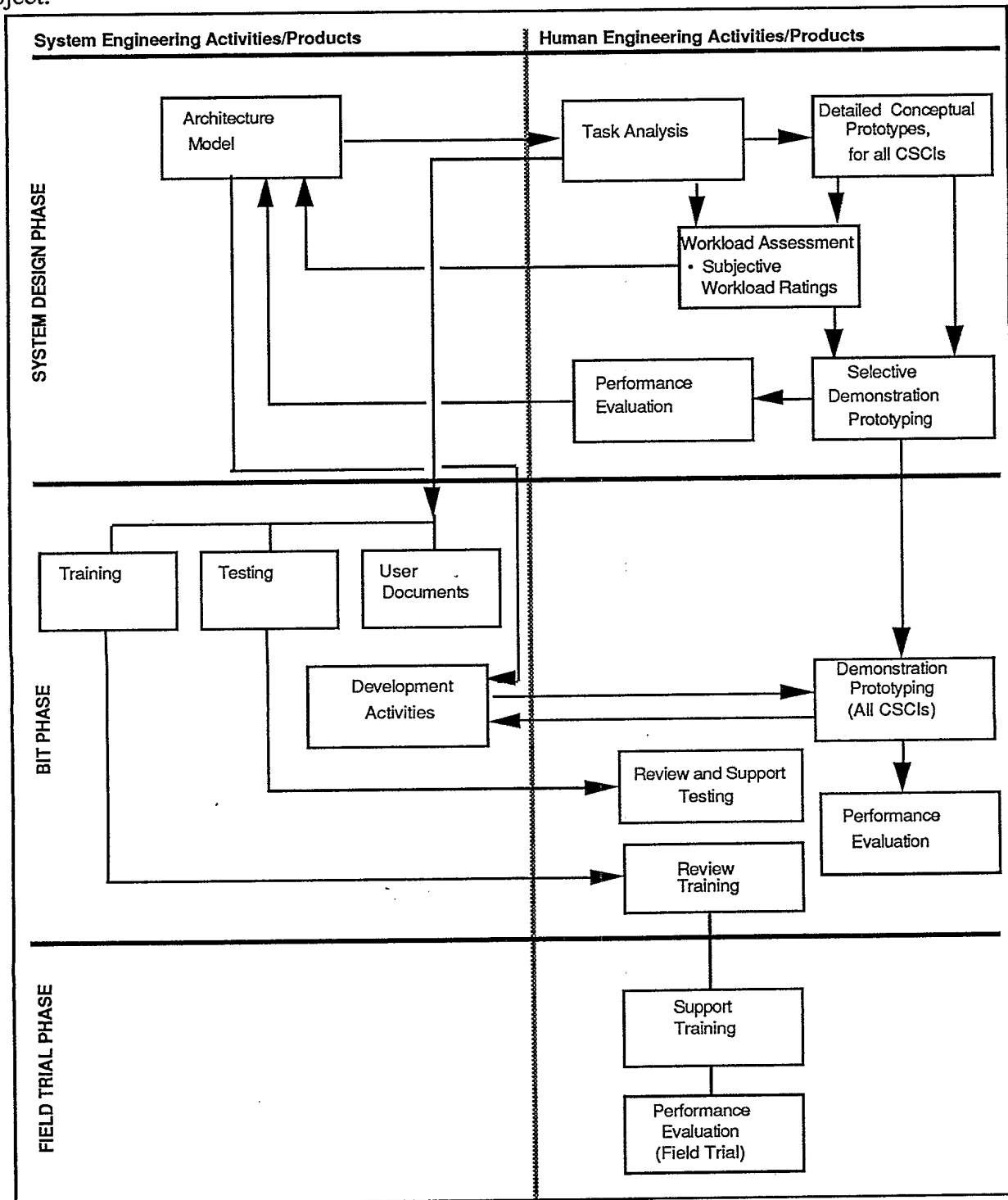

Figure 4: HFE activities planned for System Design (Phase 3) and subsequent phases of ARDS/ADM (after Clemens, 1993)

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Conclusions

The review of HFE planning in the ARDS/ADM project shows that the human engineering plan evolved as more importance was placed on HFE. There has been significant increase in HFE effort in some areas, and the HFE effort has been expanded from concentration on hardware ergonomics issues to include operator functions and tasks. This supports previous observations that the HEPP plays a major role in establishing a level of HFE activity that is acceptable to the PMO (Beevis, 1987). Despite these changes, it has been difficult to integrate all HFE activities with other system engineering activities.

THE WORKSHOP AND TRAINING COURSE

During the workshop the PM concluded that the ARDS/ADM project lacked an explicit link to user validation in the person of the a Human Factors Specialist but "given deep pockets and lots of time" that should be changed. His proposals for such a change involved an HFE specialist in each major project activity as part of the dialogue with the users (Figure 5). Although the majority of the team did not share the opinion that a specialist was needed, a Human Factors specialist was added later to the MDA team (Oct. '93).
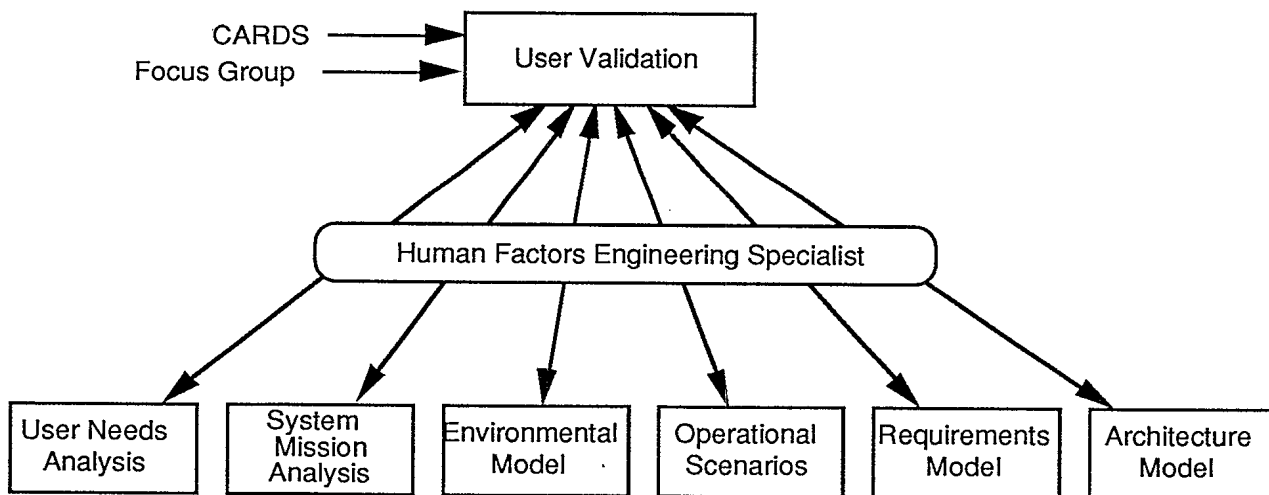
Figure 5: PMO proposed modification of the ARDS/ADM Human Engineering Management Plan

Follow-up to the Workshop

Reactions to the report on the workshop were solicited from the ARDS/ADM contractor's team (Table 1). The table shows that the workshop did not meet all the expectancies of the contractor's team. However, the workshop did achieve consensus on the need to take a user-centred, evolutionary approach to CCIS development and identified a possible way forward.

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**Table 1: Comments from the MDA project engineer, system engineer,
and the PM concerning the workshop report**

*Q.1: After receiving the workshop report: Did you read it completely?   if not, which sections did you read?
and why did you read these sections?   why did you not read the whole report?*

• Went over the material again, in particular the conclusions and discussion sections.

• Paged through it but did not take a close read.

• Gave particular attention to the summary sections and proposed model of HFE to CCIS development.

Q.2. Have you used material from the report in discussions?   if so, how and when?

• Will refer to it when needed.

• Not yet, but perhaps as part of Phase 3 planning.

• Used the material several times since workshop: publicised the availability of the report to all
contractors/companies who are interested in further CCIS work; asked those involved with future projects to
read it.

Q.3. Have you used it in other ways, e.g. for reference?   how it was used?

• It helped me to develop the training course agenda and be more precise in what we needed.

• Recommended it to other people to read the abstracts.

• Refer to it on a regular basis.

Q.4. What function or value could it have for you in the future?

• It exposed us to the HFE discipline; the presentations on life cycles and prototyping may not be very
applicable to us but it is useful to know what the extremes are.

• For planning future work.

• Will be used in discussions of future projects.

Q.5. Are there issues in the report that you would like to be addressed in more detail?

• No.

• The HFE course better addressed the direct needs of a system engineer.

• Level of detail is adequate for my use. Additional work is required on the proposed model.

Q.6. Are there issues about human factors engineering which the report does not address?

• No.

• I had hoped the meeting would give some specifics about the factors, forms of analysis, approaches, tools,
etc. that would be useful to system engineering. At least the workshop sensitized the team to the HFE
issues.

• The issue of a business case for HFE in any CCIS project is absent from the report. Little concrete
evidence was received from the participants on the cost effectiveness of such an approach. What value did
the extra money gain? Tough questions which need metrics and data to address.

Q.7. Are there other comments you would like to make about the report?

• On the Workshop: my interest was to understand if our HFE plan and approach was effective, and do I
have the right skill set. I expected the audience to provide constructive input. Instead I felt that some of the
presentations were off the subject and people were pursuing there own interest. ARDS was discussed quite
late in the workshop. On the Report: well done and excellent record of the workshop.

• None.

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Training Course

Following the workshop, the ARDS team at MDA discussed their reactions and identified their requirements for additional training, specialist human factors support, user involvement, and 'cognitive modelling' which they communicated to the PM. MDA organised an in-house HFE course by Dr. Scott Overmyer of George Mason University, from 20 - 24 Sept. 1993 to address the teams' perceived need for training. With input from DCIEM, course content was tailored to emphasize the application of techniques for iterative user-centred development. Summarized, major considerations for the ARDS/ADM team were:

- What techniques to employ?
- How important are HFE activities relative to other project activities?
- In what areas does the team need further HFE expertise?
- Prototyping: To what detail? Should it be the centre of the HFE activity? What additional value does developing a user profile add when prototyping?
- Task analysis: In what form? To what detail? How will cognitive modelling impact the user interface design? How to address tasks that are not performed currently?
- Workload analysis: What input material should be used?
- How should users and other stakeholders be involved in prototyping?

The course addressed the following topics:

- The HFE Systems Approach
- System Development Life cycle models
- Task Analysis and Function Allocation; use of Operational Sequence Diagrams
- Role of prototyping: for requirements validation, for design of user interface
- Prototyping tools
- User interface design and dialogue design
- Usability evaluation; Performance measurement.

Worked exercises in function allocation, task analysis, generating an Operational Sequence Diagram (OSD), and creating a prototype were particularly valuable for providing a feel for the costs (resources) and benefits (design decisions) of these techniques to the ARDS/ADM project.

In the discussions, the PM pointed out that the ARDS/ADM project approach is first, to specify the 'possible' and subsequently, to identify what is feasible. To arrive at a broad view of the future system all aspects of the system should be analysed which requires a complete and detailed function/task analysis to derive complete user and system requirements. Requirements that are not addressed in the current system could be incorporated in future developments, which is in accordance with the ADM evolutionary concept.

Results of Workshop and Training Course

In order to get a view on what the effects were of this HFE input, a pre- versus post-HFE input comparison was done. The items selected for comparison were taken from the contractor's HEMP and the presentation by the Project Engineer at the workshop (Clemens, 1993). Table 2 provides an overview of the effects.

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Table 2: Summary of overall effect of the Workshop and Training on the ARDS/ADM project

PRE- WORKSHOP & TRAINING COURSE APPROACH	POST- WORKSHOP & TRAINING COURSE APPROACH
HEMP	
• HFE principles will be incorporated into the:	• HFE Plan for Phase 2 was proposed during workshop to involve HFE specialists in user validation activities associated with mission analysis, environment model, operational scenarios, & requirements model, and architecture model.
System Requirements Analysis (Phase 2)	
System Design (Phase 3)	
Implementation (Phase 4 Build Integrate and Test)	
Evaluated in the Field Trials (Phase 5)	
ORGANISATION	
• Coordinate HFE activities with all other project activities	• Result of increased level of HFE effort is that not all activities are coordinated with others
• Human Engineer also has system engineering responsibilities	• A human factors specialist has been added to the team.
• Help ensure engineering activities are coordinated with, and supported by, the project's general system engineering approach and methodology	• The Architecture model has not served to integrate the HFE activities with system engineering (Note: because of delay in finishing the Requirements model, the Architecture model activity was not started in this phase)
RELATIONSHIP TO OTHER ORGANISATIONS	
• Internally, MDA-HFE was to be coordinated with System Engineering, Hardware Engineering, Software Engineering/Development.	• See Organisation above
• Externally, MDA-HFE efforts were to be coordinated with DCIEM, DLAEEM, CARDS, TCCCS/IRIS	• MDA -HFE has maintained coordination with DLAEEM, CARDS
HFE TASKS	
Main tasks of HEMP were to be	
• HFE studies	• Functions and tasks for the FOO were examined and a pen-based solution explored. A prototyping environment was defined.
• Function allocation analysis	• Functional decomposition of QFP developed by TRLO. MDA-HFE put a lot of effort into FA analysis - developed novel approach
• Review of potential operator capability	• MDA-HFE has found no suitable technique for 'Analysis of potential operator capability'
• Task analysis	• A functional decomposition was done of several missions. Little effort has been put into task analysis
• Analysis of critical tasks (as needed)	• QFP analysed

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REPORTING

Reporting plans included

- HFE Management plan
- Monthly project reports

- Project Review Meeting (PRM) reports
- HFE progress reports
- HFE special reports

- Design review meeting reports

- HEMP last revised June 1993
- Monthly meetings (including teleconf) are controlled by the PM.
-
- Made during the PRM
- Tech Notes produced for use within project team on Function Allocation, Task Analysis etc.
- Scheduled for September.

QUESTIONS FROM MDA

- Use of Military Occupational Classification (MOC) for determining operator capabilities?

- Object-oriented methodology and HFE?
- Use of prototypes to document interface and design requirements?
- Task Analysis, Workload Analysis, Performance Predictions Techniques?

- 'Groupware' applications experience?
- GIS-COTS criteria, colours?

- Little progress has been made: DCIEM learned that some, but not all, members of MOCs of possible users may be trained in typing
- DCIEM have started investigation
- This was discussed briefly at the workshop; it is possible
- Covered in the training course; PM and contractor have investigated MS Project, DCIEM are investigating SOLE
- No progress
- 40 references of GIS applications provided by DCIEM; no progress on other topics

KEY POINTS IN WORKSHOP

- Need for HFE specialist?
- Managers general knowledge of HFE?
- What training is available?
- What else is prototyping good for?
- How can prototyping be incorporated in project plan?
- User involvement - when, where, who?
- Behavioural vs. cognitive models?
- Models of groups?
- Range of skills needed for modelling
- Contract & schedule issues
- Function allocation

- Contractor has added a specialist
- Managers participated in training course
- Contractor identified source for training
- No experience to date
- No experience: DCIEM examining issue

- Evidence that must double-check expert users
- No progress
- No progress
- No progress
- No changes: under study by DCIEM
- Contractor & DCIEM developed novel approach

Work items identified at workshop were:

- Identification of stakeholders & their relationships
- Identification of problems & goals

- Exploration of goals
- Identification of organisation implications

- CARDS represents stakeholders

- No change: deficiency reports produced in Phase 1
- In progress
- Implications for doctrine & organisation identified through CARDS

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• Development of user participation plan	• No progress
• User analysis	• No progress
• System, organisational & training analysis	• Scheduled for Phase 3
• Specification of performance goals & criteria	• Some progress
• Concept development, allocation of functions, concept exploration & demonstration	• Progress based on missions & function allocation analysis
• Detailed task analysis	• Some analysis was conducted for FOO for QFP
• Detailed performance goals	• No progress
• System, interface & training system demonstration & design	• Scheduled for Phase 3
• Evaluation of functional prototype	• Story board of 1 interface reviewed
• Field trial	• Scheduled for Phase 4

Conclusions

The workshop did not meet all the expectations of the contractor's team. However it was useful in clarifying the importance of HFE in CCIS projects. It was also useful as a catalyst for increasing the level of HFE effort in the project, and in emphasizing the need to concentrate on user requirements. The report of the workshop provides a useful reference point for follow-up on lessons learned in such projects.

The course gave an overview of what useful methods and techniques are available. Tailoring the course to the ARDS/ADM project, in particular the exercise, gave the team an understanding of what has to be done and the resources required for it. The course helped focusing and consensus building for the team.

If courses are to be considered for future projects, criteria for selection should be clearly specified. Among others, these comprise: Getting an overview of techniques/tools and their pros and cons; Tailoring to specific needs of the project; Opportunities to have team discussions and exercises.

OBSERVATIONS ON
SYSTEM REQUIREMENTS ANALYSIS ACTIVITIES

List of operational capabilities deficiencies

Phase 2 of the ARDS/ADM project was designated for Systems Requirements Analysis (SRA) activities. As shown in Figure 2, a list of operational capability deficiencies (LCD) produced in March '93, was taken as input to the analysis. The LCD identified deficiencies in the functioning of the existing, manual, Artillery close support system. The deficiencies were categorised into three problem areas:
> a) information management;
> b) effective use of people;
> c) speed of operations.

Focus was on deficiencies in the timely handling of information, input, throughput, and output and reduction of errors in information transfer. Overall, statements were formulated in very general terms , for example, "It is difficult to manage ammunition restrictions and track ammunition

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availability." No performance criteria were formulated from the deficiency list. The LCD was an excellent starting point for further specifications and was used as a reference document throughout the period of the observations. For example, the LCD was cross-referenced in the System Software Specification (SSS).

Mission analysis

Developing mission analyses and function decompositions was one of the main thrusts of the System Requirements Analysis Phase. During the exercises in the post-workshop training course, it was recognised that more detail is required in task specification than was available in the operational scenarios developed up to then. Subsequently, TRLO developed function decompositions based on twelve artillery mission descriptions [2] including the Quick Fire Plan (QFP). The latter was selected as the most critical one, covering most of the activities of the artillery close support task.

TRLO developed a MS Project® implementation of the functional decomposition of the QFP with estimated timings. According to TRLO, the MS Project tool was very useful for further specifying the functionality in the mission. These narrative mission descriptions also provided information on operator functions, information display and control requirements, and timeline of activities. The time grain that could be used was limited to one-minute. The mission-based specification of the system functions was very effective and allowed the expert users (CARDS) to discuss choices. An example of a mission specifying the functionality is given in Annex A. An example of the timeline representation is given in Annex B. Part of the description of the same mission with system specifications presented at the System Requirements Review is given in Annex C.

Narrative mission desctiptions were developed by only one subject matter expert, but were later checked by a second, and verified by the CARDS.

Function allocation

Function allocation is the assessment of system functions defined in the mission descriptions in order to determine respective roles of the computer system and the human. System functions were derived from the Operational Concept Definition completed in Phase 1 (by Bombardier); others were derived from DND publications on artillery doctrine. The LCD was used to cross-check that the functions covered all problems areas. Information from other systems engineering activities, such as the development of data flow diagrams, was not used to derive system functions.

The MDA human factors specialist prepared a function allocation screening process of 18 binary decisions based on relative human and computer capabilities from Fitts (1951) and Bekey (1970). User experts (TRLO and DPM) made a preliminary function allocation analysis using the process. The result was a summary of function/task elements in terms of a human-computer allocation balance. MDA found that this gave a gross allocation and that further analysis was needed: some allocations were ambiguous or mixed, i.e., they could be allocated to either a human or a computer or to both.

The DCIEM representative suggested that the mixed allocation and the uniquely human allocation were both candidates for further analyses. In both instances the human would perform the task, but could be supported by the computer. DCIEM discussed the iterative nature of function allocation

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[2] The project team referred to these analyses as 'scenarios.' In HFE terms they are narrative mission descriptions (Beevis et al. 1992) but the use of these terms is not standardized (ibid). Some authors use the term 'scenarios' for analyses of a short sequence of detailed operator tasks, or actions (Neilsen, 1993; Young & Barnard, 1987).

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and the relationship between function allocation and support (Figure 6). The PM suggested including this figure in the ARDS/ADM documents.
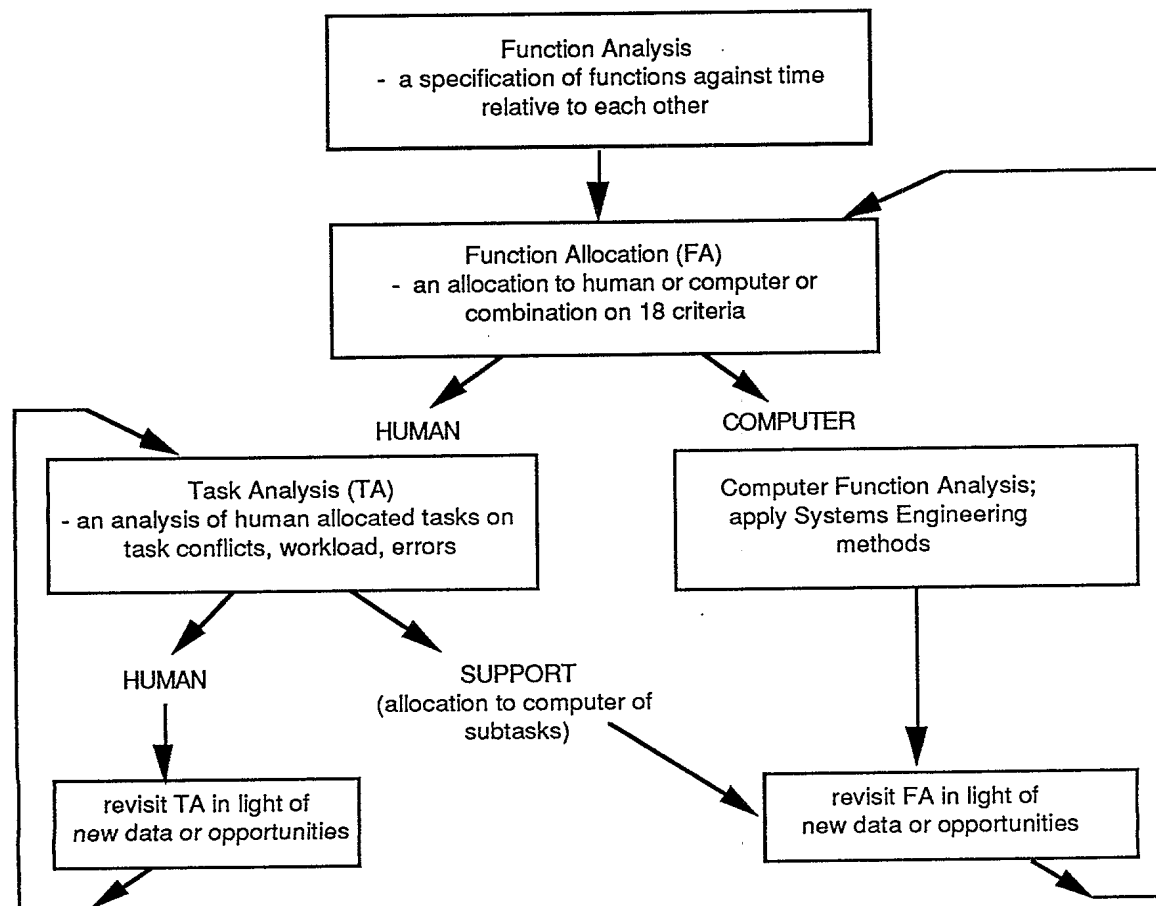

Figure 6: The approach to Function Allocation developed for ARDS/ADM

The proposed function allocation assessment results in three categories of functions:
1. Computer allocated functions
2. Human allocated functions
3. Mixed allocations, in which the computer supports the human.

Functions allocated to computers are unambiguous. Mixed allocations are more problematic, in the sense that these require a more detailed assessment as to what functionality is required. In principle, function allocation could change the overall functionality of the system. This supports the argument that function allocation should be performed early in the system development, preferably early in conceptual design (operational concept definition).

This function allocation method was used by one subject matter expert to assign the functions identified for ARDS/ADM. The method identified which aspects of the ARDS/ADM functions required computer support. This will specify additional computer functionality which has to be worked out in Phase 3. An example of the function allocation tables used in ARDS/ADM is given in Annex D.

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As outlined above, the function allocation tables resulting from the HFE analysis activities could be used to assess the specification of the functions in the System Software Specification (SSS). For instance, "are the functions 'produce grid reference' and 'indicate unsafe targets' in the QFP scenario supported by the SSS?" The SSS should also be assessed on the functionality assumed in the other mission analyses.

Task analysis

As shown in Figure 2, task analysis was not a priority during the early part of the System Requirements Analysis phase. Task analysis was often considered in conjunction with function analysis and function allocation. This can be seen from the scenario decompositions shown in Annex A, which are essentially operator task descriptions.

Task analysis was a subject of concern during the period of observations following the workshop. Specific concerns were the techniques to be used, and the level of detail required. OSDs may be the most suitable way to present the sequential and parallel tasks of the operators.

Initial task analyses focused on the Forward Observation Officer (FOO). Attempts to produce story-boards of sub-systems lead to a loss of focus in the analysis. For example, consideration of the utility of pen-based computer terminals dominated early discussions of system requirements. Only when the pen-based interface was rejected did the focus return to task analysis, concentrating on the Battery Commander (BC).

DCIEM suggested that the implementation of the QFP using the Systems Operator Loading Evaluation (SOLE) software being developed for DCIEM by Canadian Marconi would be an interesting exercise for both the ARDS/ADM project and DCIEM. SOLE supports a series of human engineering analyses, including the systematic decomposition of system functions through three levels, function allocation, task analysis using OSDs and workload assessment using a task network simulation. DCIEM suggested that implementation of ARDS/ADM analyses in SOLE might facilitate function and task analysis and workload prediction.

A trial application of SOLE based on the QFP showed that more detailed task analyses were required. The implementation also showed that the information developed to that point was mixed at several levels of function and task description. Although the use of SOLE pointed at those inconsistencies in the existing decomposition, the experience showed that the SOLE software was not sufficiently mature to be used on the rest of the project without risk of delays or mistakes in the analysis.

Prototyping

How much prototyping to do, and when to do it, were subjects of concern at the workshop and during the subsequent ARDS team training. Subsequent experience using story-boarding showed the positive and negative aspects of prototyping. Story-board screens were prepared which reflected the opinions of the SME and some of the systems engineers that a pen-based interface could be used to assist the FOO in his planning process.

When the story-board screens were reviewed during the October walk-through, some concerns were raised with regard to the suitability of the pen-based systems. It was suggested that it might be more appropriate to do the story-board for a QFP prepared by the BC. Another user, the DPM, stated that the FOO does not need to do fire planning at all: the FOO is essentially a target acquisition device and should be viewed by the system as, say, a radar. To address these different views, the approach and analysis were reviewed and subsequently updated.

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This experience showed that some of the uncertainty associated with system requirements could have been reduced by prototyping. The negative aspects were that the production of the story-board of the pen-based interface for the FOO diverted project team effort from other activities. However, it was recognised that the interface concept could be used elsewhere, for example, by the BC. According to the development team, the iterations on the prototype helped the team and the TRLO to come to a common understanding.

Story-boards of display pages showing how they would be implemented in MOTIF were also developed by TRLO for his briefing to the System Requirements Review.

System Requirements Review

A System Requirements Review (SRR) covers work completed in the System Requirements Analysis (SRA) phase. The contractor's plan, as described during the Workshop (Clemens, 1993), was to include the following major HFE activities in the SRA Phase (see Figure 2):

- Review User Needs Analysis and System Mission Analysis
- Function Allocation Analysis
- Task Analysis
- Workload Assessment
- Conceptual Prototyping (identification, prototyping, and review of user interfaces)
- Define a Prototyping Environment
- Evaluate User Interface Hardware
- Develop User Interface Guide
- Perform HFE Planning and Documentation.

Although the training plan is implicit in the review of Logistics Support Analysis, which is a topic called up in the standard covering SRR (MIL-STD-1521B - Technical reviews and audits for systems, equipments, and computer software, US DoD, 1985), the training plan was not scheduled until Phase 3 of the project. During the Workshop, it was argued that the training plan should be produced earlier in the development cycle (Beevis, Essens & Mack, 1993, p 134). The list of 'Review Points/Deliverables' for a user-centred approach, produced at the Workshop suggested that the SRR should include:

- Scenarios and performance specifications
- Analyses
- Prototypes
- Draft manning and training plan
- Plan for resolving issues (related to usability and user requirements)
- Draft requirements specification.

Implementation of this plan would add two additional HFE work items to the planned SRA activities: the identification of performance specifications, and the preparation of a draft manning and training plan. In addition, it would require the work under some of the other headings to be expanded.

The SRR took place in February 1994. In contrast with the work items and deliverables listed above, the SRR covered the following topics:

- Mission and requirements analysis
- Functional flow analysis
- Preliminary requirements allocation
- System/cost effectiveness analysis
- Trade studies.

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Table 3: Summary of reactions from 19 attendees to the System Requirements Review

Q. 1 : Did the day go according to your expectations?
- 19 positive responses, several commenting on the value of the scenario approach

Q. 2: What is the most important point which you felt was addressed today?
- Answers ranged through: understanding of Arty operations and where ARDS might help; realising that the users expectations differed from the contractors analysis; the value of a GIS; requirements for the database; user interface requirements

Q. 3: Did you get good insight in what the ARDS/ADM will be as an end product?
- 13 - yes; 4 - equivocal; some suggesting it gave assurance ARDS was on the right track; 2 - no

Q. 4: Was the amount of detail dealt with sufficient or too much?
- 18 - yes or sufficient; two suggested more time or detail was required

Q.5: How adequate was the functionality shown? What would you like to see added? Explain specific concerns.
- 1 - excellent; 4 - good; 7 - adequate; 1 - no, 3 - need more detail; 1 - too early to tell; 4 - thought more detail required; 1 - thought more detail would cloud the issues

Q. 6: Did you miss anything that should have been discussed?
- 14 - no; four other comments were positive

Q. 7: How did the approach by Capt Marston (scenario perspective) work for you?
- 3 - excellent; 4 - very good/well; 10 - good/well; 2 - yes

Q. 8: Was there enough opportunity to interact with the participants and to discuss issues?
- 17 - yes; 1 - more would be nice

Q. 9: Did the demonstrations give additional insight into the functionality of the system? Was the functionality in the demo different from what you understood from the paper-based presentation or was it more a (welcome) repetition?
- 1 - yes; 3 - welcome repetition; 8 - complemented/added insight; 1 - no

Q.10: Would you have liked to operate the demo of the prototype yourself?
- yes - 3; no - 12

Q.11: Would you like to have seen more open discussion?
- 2 - yes; 7 - enough/adequate; 8 - no

Q.12: Were the issues raised reviewed enough and resolved?
- 13 - yes/comprehensive ; 1 - acceptable give time frame ; 6 - issues remain/more detail needed

Q.13: Do you have other comments?
- Good experience
- A lot was accomplished
- Good level of detail - liked the process and outcome of user involvement
- Format was excellent - this type of meeting is essential in early stages of the project
- HFE and scenario work should be done before the SSS - discussion could significantly affect direction of the specs.
- More departure from the traditional Art approach makes it critical to prepare/educate the user
- More relationship to data and between screens and functionality
- Close interaction with industry partners should be encouraged

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The SRR was organised in two parts: first a presentation of detailed mission/function/task analysis for the QFP in the context of a military scenario related to the ARDS/ADM ('the scenario-based approach'); then a discussion of the more system engineering-oriented System Software Specification

(SSS) document. The aim of the TRLO, who was responsible for the first part, was to solicit feedback on requirements. He noted that the SSS is an engineering document meant to be used by the contractors, the PM, and the Project Director. It does not always represent the specifications in a language that is easily understood by the eventual users of the system. The scenario-based approach and the related conceptual prototype were received very well by the audience, comprising the team plus representatives from the user community (including CARDS).

In contrast to the one and a half day review of the mission descriptions, the review of the SSS was an intensive, somewhat tedious process, because it was hard to deduce usability from the terms of the specification. DCIEM found it difficult, for example, to assess which functions supported planning. It was agreed that the SSS should at least refer to the operator task lists which were being generated for each mission description, in the form "support the preparation of plans involving the following tasks ..." Some participants, including DCIEM, suggested that this format would be fully adequate for a SSS. The mission-based specification would serve as the users' perspective of the SSS; the system developer's perspective could be added as a second part. Functions in both perspectives would be cross-referenced. Two of the subcontractors were particularly positive, and argued that the SSS review would be unnecessary if the design were based on such mission analyses and their resulting functionality. A survey of the reactions to the System Requirements Review and the SSS discussions is presented in Table 3.

Conclusions

Narrative mission descriptions and function analysis can provide the link between user requirements on one hand and the engineering perspective and the system structure on the other hand.

Function allocation (FA) decisions identify automation opportunities. Because FA was done by only one expert, no claims are made that this allocation is definitive. Further verification of the automation suggestions is expected in Phase 3.

The failure to implement the plan for deliverables, developed in the workshop, in particular the training plan, is understandable in view of the contractor's original plan to schedule training development for Phase 3.

The SSS was difficult for the user community to understand. In contrast, a description based on the narrative mission descriptions gave the users the opportunity to understand the functionality of the future system. The level of detail provided by the mission descriptions seemed to be appropriate.

The prototype did not seem to increase the users' understanding of the future system beyond that provided by the scenario-based system specification . For the development team, the iterations of the prototype helped the team and the TRLO to come to a common understanding of interface requirements.

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OBSERVATIONS ON USER INVOLVEMENT

Stakeholders - CARDS

Reflecting the need to produce an effective system, the organisation of the project included a requirements officer, a user representative subject to the direction of the Committee on ARDS (CARDS, formerly the Artillery Doctrine Authority Committee), and a trials unit. CARDS met every two months and provided a medium for users to review the project.

The DCIEM representative (Essens) attended the meetings in September '93, November '93, and January '94. These meetings were useful for identifying important issues for the contractor's team. For example, during the November meeting the contractor identified the need to focus on a critical task and analyse it in detail. The Quick Fire Plan (QFP) was selected. The TRLO developed 12 detailed mission descriptions, which were passed to the CARDS committee for evaluation.

Stakeholders had the opportunity to review the functional specifications for the projected ARDS/ADM when TRLO presented them during the January meeting.

Use of subject matter experts

Two subject matter experts (SMEs) were involved regularly in the project. One, the TRLO, spent more than half his time in the contractor's plant. The other subject matter expert, the DPM, spent most of his time in the project office. There is a need to provide on-site user input from more than one expert on an ongoing basis. The limitation to one was because of costs. The two SMEs sometimes had diametrically opposed views on technical solutions, for example, as to how ARDS should support the FOO:
- Supply FOO and his tech. with Field Data Terminals (FDTs) which have a GIS and planning support tools plus target acquisition utilities
- Supply him only with the means to determine target locations and the means to get these locations into the system.

That users may hold differing views is not surprising. It has been shown that members of a group will slowly change their judgment criteria to be more in accord with the opinions of the majority (Wrightsman & Deaux, 1981). Thus the TRLO, who is involved in the project on a ongoing basis, may well have a different opinion from a user representative brought in from outside for the purposes of a review.

Conclusions

The CARDS proved to be a useful medium of communication between the stakeholders and contractor's team. It permitted contractors to raise points of concern, it provided guidance to the contractors, and it permitted stakeholders to review contractor's proposals.

The in-house subject matter expert provided useful guidance on a continuing basis. The availability of a second expert improved the validity of the SMEs perspective. There is an obvious need to provide user input both from a team member on a continuing basis and from outside the team for periodic reviews.

Overall, however, user input to the SRA seemed to be insufficient. CARDS did not provide enough user input to avoid problems in day-to-day developments. The differences of opinion between the two SMEs on certain design features showed that a broader users' perspective is required.

CONCLUSIONS AND RECOMMENDATIONS

The ARDS/ADM project has shown a considerable increase in HFE effort which is mainly a result of the PM's initiatives and the willingness of the contractor to address HFE. Effort for HFE was not well-defined at the start of the project and the general consensus on the contractor's side was that it could be dealt with using existing system engineering methods and expertise. This was identified as incorrect by PMO and contractor and the approach was changed.

The workshop was the first explicit action to augment the PMO's and contractor's understanding of HFE. The workshop gave a broad picture of HFE issues in the development of CCIS. Although it was not specific enough and did not meet all the expectations of the contractor's team, it was useful in clarifying the importance of HFE and a user-centred approach. The workshop served as a catalyst for increasing the level of HFE effort in the project.

The training course was highly appreciated by the ARDS/ADM team. It gave the opportunity to formulate questions on HFE applications and to learn and practice relevant techniques. The course helped focusing and consensus building for the team.

The interaction between two streams of activities, system engineering and HFE, was less than expected. It was difficult to integrate all HFE activities with other system engineering activities. This may have been due to the evolution of HFE effort during Phase 2 of the project. It may also have been due to the delay in starting the Architecture model. The idea that the Architecture model served as a platform for integration of the HFE results remains to be tested in Phase 3. It is not clear how the function allocation analyses and the task analyses will affect the architecture model, and vice versa.

Mission descriptions can provide the link between user requirements on one hand and the engineering perspective and the system structure on the other hand. In conjunction with the LCD, mission descriptions made a significant contribution to understanding and specifying the system requirements (SSS), and discussing problems and design solutions. Mission descriptions, in conjunction with LCDs, could also provide the basis for establishing test and evaluation criteria.

The approach taken to function allocation (FA) identified opportunities for automation and for operator aiding which should be reflected in the system software specification.

The prototyping activities did not seem to increase the users' understanding of the future system, compared with the mission descriptions. However, insufficient experience was gained with prototyping in this phase to permit conclusions to be drawn.

The CARDS and the TRLO represented the user community. CARDS functioned effectively as a long-distance guidance and correcting mechanism, but the time between reviews was too long in some cases. The TRLO served as an effective on-site source of information and guidance. However, there is a need to provide on-site user input from experts on an ongoing basis, and from outside the team for frequent periodic reviews.

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Recommendations

HFE requirements should be made more explicit and detailed in the Statement of Requirements for future CF CCIS projects.

Training courses are recommended for future projects where the contractor lacks in-house experience in HFE. Criteria for selection of training courses should be clearly specified, and the course tailored to the requirements of the contractor's team.

The System Engineering Management Plans for future CCIS projects should make explicit the relationship between system engineering and HFE activities.

Lists of Capability Deficiencies should be exploited in future CF CCIS projects.

The use of narrative mission descriptions should be exploited in future CF CCIS projects.

The approach to function allocation developed in the ARDS/ADM project should be considered for adoption in future CCIS projects.

User representation should be increased in future CF CCIS projects based on the ARDS/ADM model.

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ACKNOWLEDGMENTS

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LIST OF ABBREVIATIONS

ADAC - Artillery Doctrine Authority Committee

Arty - Artillery

BC - Battery Commander

BIT - Build, Integrate, Test

CARDS - Committee on ARDS

CSCI - Computer Software Configuration Item

DPM - Deputy Project Manager

FDT - Field Data Terminal

FOO - Forward Observation Officer

GIS - Geographical Information System

HE - Human Engineering

HEMP - Human Engineering Management Plan

HEPP - Human Engineering Project Plan

HFE - Human Factors Engineering, synonymous with Human Engineering

LCD - List of Operational Capability Deficiencies

MANPRINT - Manpower and Personnel Integration

MDA - MacDonald-Dettwiler and Associates

MOC - Military Occupational Classification

OSD - Operational Sequence Diagram

PM - Project Manager

PMO - Project Management Office

QFP - Quick Fire Plan

RA - Requirements Analysis

SD - System Design

SE - System Engineering

SOLE - System Operator Loading Evaluation

SRA - System Requirements Analysis

SRR - System Requirements Review

SSDD - System/Segment Design Document

SSS - System Software Specification

TAD - Target Audience Description

TRLO - Technical Requirements Liaison Officer

ANNEX A: SCENARIO ARTILLERY OPERATIONAL PLANNING PROCESS

Annex A. 2

Arty Operational Planning Process. This scenario describes the process that an artillery commander would follow to produce orders when time is available and the operation is complex. This is usually the case for operations at the division level and above. Only in very rare cases would this process be followed at the bde/CS regt level. In this scenario the artillery commander is the Commander Division Artillery (CDA), who is the commander of the Division Artillery Brigade (Div Arty Bde).

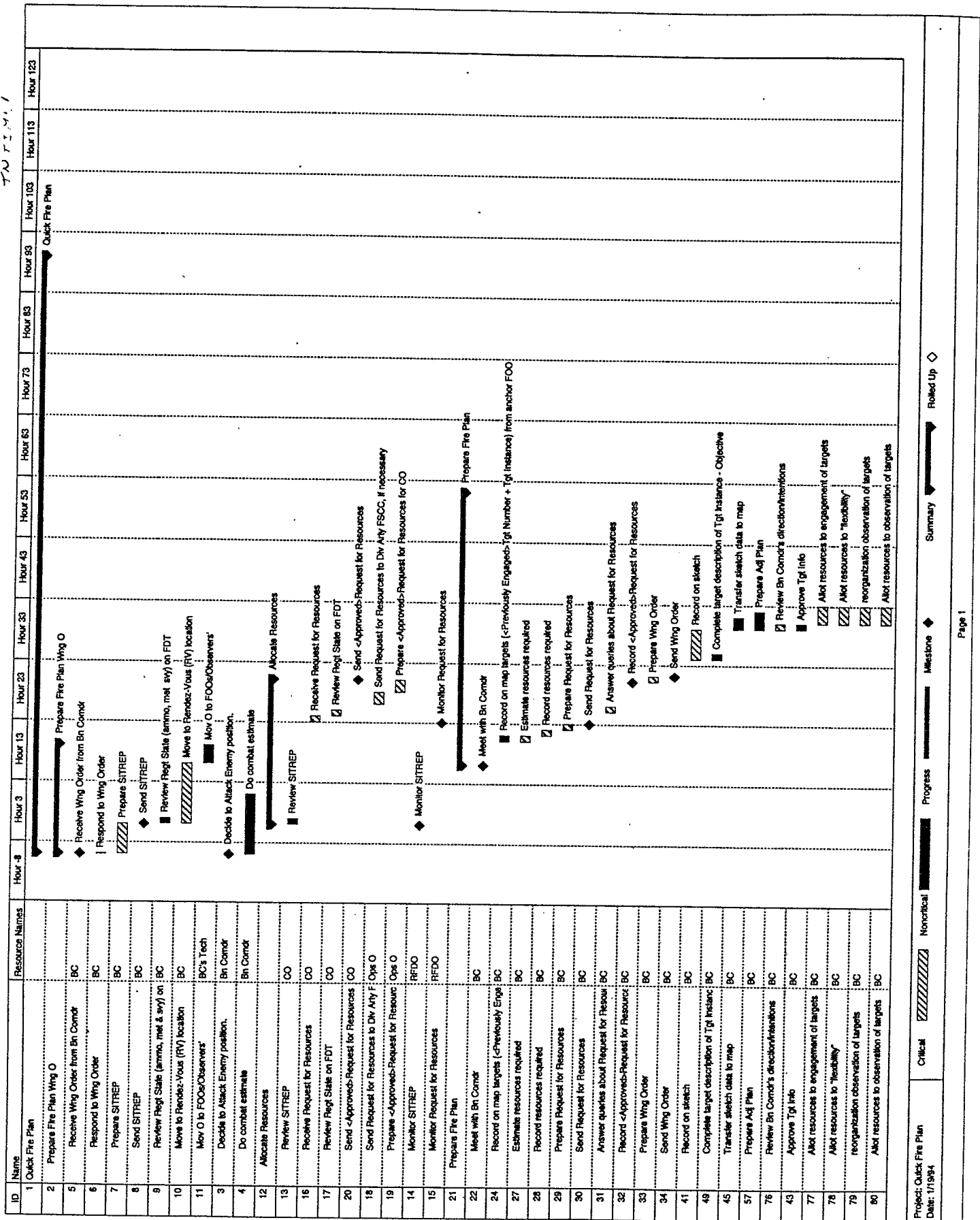| STEP	EVENT - PROCESS - ACTION
1	Task received - this is the notification to the CDA that planning is required. The Div Arty Bde will get Warning Orders from Corps Arty HQ and Div HQ. A Wng O may also be produced by the CDA in anticipation of future operations.
2	Conduct quick time estimate. The CDA makes a plan for how he will use the available time to prepare and issue orders. A critical decision is when he will issue orders.
3	Conduct quick map estimate. Before doing a complete estimate, the CDA will quickly look at the map. He will see where the guns are now, what the terrain is like in general terms and where the enemy is now and likely to be. A more detailed map estimate will be done later. The CDA will be supported by the Arty Chief of Staff (COS) who will do mission analysis, the G2 (DAIO) who will analyze enemy intentions and the A/COS Adm who will review the admin situation.
4	Prepare and issue Wng O. The Wng O will be as detailed as possible depending on the information and time available. It will be based on the quick map estimate to produce a basic plan if possible. It will be sent to the regiments and staff officers in the bde. This will be the first formal notification to the COs that an operation is pending. It will start their planning following the battle procedure process.
5	Corps Fire Sp Annex received. This will be received by the bde at about the same time the Div HQ receives the Op O from Corps HQ. It will tell the CDA what the Commander Corps Arty (CCA) expects him to do and what resources he has to support his div. These orders may be received at Corps HQ, by courier or by radio. If a Corps O Gp is held, the CDA will attend with the Div Comd. After the O Gp, the CCA will meet with all the CDAs for his own O Gp.
6	Detailed time estimate. Once orders have been received the CDA will do a complete time estimate. This will confirm his earlier time estimate and guide him in how he allocates his own time.
7	Mission analysis. Mission analysis is the initial step in the estimate by which the CDA translates the task given to him into the aim for his own estimate. The purpose is to ensure that the CDA has a full understanding of his mission and to identify the tasks essential to accomplishing the mission. The CDA must thoroughly understand the mission of the Corps and the concept of ops of the army.

Annex A. 3

8	CDA's initial estimate. The CDA will do an estimate to produce planning guidance for the staff. The factors are the same ones listed in the arty battle procedure scenario. Planning guidance tells the staff how the operation will be conducted in broad terms. It should include: The aim - from Msn Analysis What the CDA wants fire support to do to the enemy Where, when and what must be accomplished Critical enemy vulnerabilities Desired end state Special concerns The CDA will advise the Div Comd on fire support, so that the Div Comd's estimate takes into account fire support. At the same time the CDA must know what the Div Comd's plan is when doing his own estimate.
9	Staff conducts studies in their own areas of interest. These are estimates in their own right that lead to plans in each of the areas. Each of the responsible officers (G2, COS, A/COS) will provide advice to and get guidance from the CDA. This activity will involve assessing the enemy reaction, developing courses of action and selecting the best course of action. The CDA will be very involved in the later stages of this activity. This stage is also the stage during which the arty staff will provide fire support advice to other members of the Div HQ as the do their estimates for the Div Comd.
10	CDA details his concept of operations. The concept of ops is how the CDA (on behave of the Div Comd) wants to conduct the fire support battle. It should include: What fire support resources are to accomplish Target priorities Fire support priorities Ammunition requirements Critical timings for fire support The concept of ops is based on the selected course of action and lets the staff turn the outline plan into detailed orders.
11	CDA approves orders and signs.
12	Issue orders. The orders may be issued by radio, at an O Gp, by courier or digitally.
13	Coordination - Monitoring. Once the orders are issued the CDA monitors their execution. Input from his subordinates and the manoeuvre forces returns him to the first step and the cycle repeats until new orders are issued to deal with the changing situation. These cycles will usually be abbreviated and will not appear to go through the full cycle. The time to complete subsequent planning may vary from seconds to hours with seconds being the norm.

Annex B. 1

Annex B: Time line representation Quick Fire Plan Scenario

ID	Name	Resource Names
1	Quick Fire Plan	
2	Prepare Fire Plan Wng O	
5	Receive Wng Order from Bn Comdr	BC
6	Respond to Wng Order	BC
7	Prepare SITREP	BC
8	Send SITREP	BC
9	Review Regt State (ammo, met & svy) on BC	BC
10	Move to Rendez-Vous (RV) location	BC
11	Mov O to FOOs/Observers	BC's Tech
3	Decide to Attack Enemy position.	Bn Comdr
4	Do combat estimate	Bn Comdr
12	Allocate Resources	
13	Review SITREP	CO
16	Receive Request for Resources	CO
17	Review Regt State on FDT	CO
20	Send <Approved>Request for Resources	CO
18	Send Request for Resources to Div Arty F	Ops O
19	Prepare <Approved>Request for Resourc	Ops O
14	Monitor SITREP	RFDO
15	Monitor Request for Resources	RFDO
21	Prepare Fire Plan	
22	Meet with Bn Comdr	BC
24	Record on map targets (<Previously Enge	BC
27	Estimate resources required	BC
28	Record resources required	BC
29	Prepare Request for Resources	BC
30	Send Request for Resources	BC
31	Answer queries about Request for Resou	BC
32	Record <Approved>Request for Resource	BC
33	Prepare Wng Order	BC
34	Send Wng Order	BC
41	Record on sketch	BC
49	Complete target description of Tgt Instanc	BC
45	Transfer sketch data to map	BC
57	Prepare Adj Plan	BC
76	Review Bn Comdr's direction/intentions	BC
43	Approve Tgt Info	BC
77	Allot resources to engagement of targets	BC
78	Allot resources to "flexibility"	BC
79	reorganization observation of targets	BC
80	Allot resources to observation of targets	BC

Project: Quick Fire Plan
Date: 1/19/94

Critical ▨▨▨ Noncritical ▆ Progress ▆ Milestone ◆ Summary ▼▬▼ Rolled Up ◇

Page 1

Annex C: 1

Annex C: Scenario with system specification presented at System Requirements Review

- **Receive Warning Order**
  - ARDS alerts users based on the type of message received, a tactical event or a time
  - Users can modify the level of the alert
  - Alerts persist until they are answered
  - User can modify what ARDS has entered and completes the remainder of the order
  - User can configure alerts, can raise level, configure what and who gets alerted for incoming events and messages
  - Messages into and out of a terminal are logged by the system

- **Conduct Time Estimate**
  - ARDS does not force a sequential series of steps in battle procedure. The user can display the time estimate tool, GIS or any other tool at any time
  - The GIS will calculate distances. Potential uses in planning:
    - Distance to O Gps
    - Distance to FEBA
    - Distance from gun positions to enemy
  - Time estimate tool
    - ARDS displays a list of the tasks for the operation being planned
    - Timings entered into the time estimate tool are automatically entered into the order being prepared
    - Estimates based on the Staff Data Handbook and RCA Yardsticks are automatically entered
    - User can modify any of the times
    - Tool calculates time each step will be completed

- **Quick Map Estimate**
  - The user can display the locations of friendly and enemy units
  - The user can display all elements of battlefield geometry such as boundaries, obstacles and objectives
  - Data gathered at any stage can be saved into the estimate and developed later

- **Prepare and Issue Wng Ops**
  - Documents can have multiple authors. For example, the CO can start the Wng O and have the Ops O complete it. Both can be at different terminals and locations
  - In writing the Wng O or any other product, the user can query ARDS for any information stored in the database. There is a set of standard queries, but users can create and save their own queries as well
  - ARDS has electronic copies of SOPs and records of unit and formation policies
  - ARDS has copies of CFPs on-line, if they are available in electronic form
  - The unit Wng O is logically related to the incoming Wng O and subsequent orders for operation. This any of the products produced during the operation that are related to each other can be easily retrieved
  - A Wng O can be based on a previous Wng O saved from the last exercise. This could be a modified version of the default Wng O provided with ARDS

- **Attending O Gp**
  - The FDT is a portable laptop. It has all the situation info and unit data stored on it, current as of the time is was disconnected from the communications system (TCCCS)
  - Users can take notes on the FDT
  - Users can connect to the HQ local network and get a copy of the orders
  - As soon as ARDS is aware of new command and control relationships, the data for those units is downloaded
  - Data for Allied fire support systems can be found using Common Technical Interface Design Plan (CTIPP) status msgs developed for AFATDS and other NATO systems. The CTIP formats are used by the US (AFATDS, IFSAS), British (BATES), German (ADLER) and French (ATLAS) systems at the moment. NATO has decided to adopt the AFATDS Common TIDP formats for A Arty P-3, one of the NATO standards for ADP interoperability. If other countries, such as Australia, chose to support A Arty P-3, then they will also be interoperable with ARDS.
  - All users are alerted when a message addressed to multiple users is sent. For example, the AMA trace and Tgt Lists can be shown on the GIS

Annex C: 2

- **Changes to a Time Estimate**
  - Data in the time estimate can be changed any time, for example new information gained as a result of attending an O Gp can be added
  - Other users of the estimate are alerted that the estimate has changed
  - Other products, such as an Op O, that uses the timings will have their timings changed as well

- **Presentation of Orders**
  - ARDS will assist in conducting O Gps by being able to produce overlays and paper copies of the orders
  - ARDS may assist in conducting O Gps by allowing commanders to project the ARDS screens and the GIS

Annex D. 1

Annex D: Function Allocation Tables

Function Allocation Table (Battle Procedure)

Functions / Procedure	Proposed: Computer	Man	Both	Req't	Mgmt	Other	Score: Computer	Man	Monitors low-probability events. / Poor at unexpected events; otherwise good.	Low absolute sensitivity thresholds. / Higher thresholds.	Can detect masked signals. / Poor signal detection in noise.	Can acquire data incidental to task. / Insensitive to extraneous factors.	Not subject to jamming. / Subject to disruption.	Good pattern recognition. / Little perceptual constancy.	Sensitive to a variety of stimuli. / Sensitive beyond human range.
1. Warning Phase															
Receipt of warning order.		✓													
Anticipation of future operations.		✓				✓									
Conduct quick time estimate.		✓				✓	2	5	H	x	x	H	x	x	x
Conduct quick map estimate.		✓					2	6	H	x	x	H	x	H	x
Get status of ammo.	✓						8		C	x	x	C	x	x	x
Information															
Get Enemy info.	✓						8		C	x	x	C	x	x	x
Prepare warning order.	✓						4	1	C	x	x	C	x	x	x
Issue warning order.	✓						6	0	C	x	x	C	x	x	x
2. Main Planning Phase															
Receipt of orders from higher HQ.	✓						3	0	C	x	x	C	x	x	x
Conduct time estimate.			✓				3	4	C	x	x	H	x	x	x
Do an estimate.			✓				3	4	H	x	x	H	x	x	x
Do an outline plan.			✓				5	0	C	x	x	H	x	x	x
Issue outline plan to Ops Officer.	✓						7		C	x	x	C	x	x	x
Recce to confirm plan.		✓					1	7	H	x	H	H	x	x	x

D-1

		Data Processing						**Data Transmission**					
Can choose alternate strategies.	Can generalize from limited data.	Computation weak and inaccurate.	Limited channel capacity.	Can store large amount of info, and recall relevant facts.	Can handle a variety of transient overloads.	Short term memory poor.	Poor tracking. Can adapt to situations.	Performance deteriorates with time.	High response latency.				
Best for repeated strategies.	Deductive processes.	Accurate and rapid computation.	Channel capacity can be enlarged.	Can store and recall large amounts of info, quickly.	Overloads can seriously disrupt.	Short term memory good.	Good tracking.	Cannot adapt to situations.	No fatigue, other time effects. Can do repeated tasks.	Can have low response latencies.			
C	C	C	C	H	C	x	x	C	C				
C	C	x	x	C	x	x	x	x	x				
C	C	C	x	H	x	x	x	x	x				
x	H	x	x	H	H	H	x	x	x				
C	x	x	x	H	x	x	x	x	x				
C	H	C	x	C	x	x	C	C	C				
C	C	C	C	C	C	H	H	x	H				
C	H	C	x	H	x	x	x	x	x				
H	x	x	x	x	x	H	H	x	x				
C	x	C	x	C	C	C	x	x	C				
H	H	x	x	H	C	C	C	x	x				

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